

# Adolescent Anterior Cruciate Ligament Reconstruction: A Decade of Rising Surgical Cost

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**S**urgical cases of primary anterior cruciate ligament (ACL) reconstruction (ACL-R) for adolescent patients (aged 10-19 years) have been increasing in the past decade.<sup>1-4</sup> Evolving growth-friendly techniques provide effective solutions that minimize growth disturbance in skeletally immature patients. The ACL is a crucial ligament that provides rotational and translational stability of the knee joint during activities. Loss of function of the ACL alters the biomechanics of the knee and may lead to accelerated joint damage. Timely surgical reconstruction is thus recommended for young, active patients with complete ACL tear in hopes of mitigating further meniscus and cartilage injury.<sup>5-8</sup>

The cost of health care in the US has been steadily increasing by a magnitude of approximately 40% and 60% from 2010 to 2022, as reflected in the Consumer Price Index (CPI) specific to medical care and hospital-specific services, respectively.<sup>9</sup> The cost of living in the US, reflected by the General CPI that is tracked and reported by the US Bureau of Labor Statistics, has increased 35% throughout the same time frame.<sup>10</sup> The cost of health care is influenced by a planned schedule from government administrations such as CMS as well as by contracts between the payers and the medical service providers in private sectors. In orthopedic procedures, the use of commercial implants can further compound such costs.

The cost of health care services can be represented by charge data and reimbursement data. Charge data include the amount asked by the health care providers (individuals or entities) for their service. Reimbursement data include the payment that is actually received by the providers from the payers (individuals and third parties). These are commonly treated as proprietary information and are thus difficult to access, despite the recent enactment of the No Surprises Act that intends to shed light on costs for patients by requiring a good faith estimate be provided to those who pay for their medical services without going through insurance.<sup>11,12</sup> Although exact reimbursement data are not always readily reportable for reasons of confidentiality, charge data are relatively more accessible. Analyzing such charge data and their relation to the actual reimbursement can provide insight into the dynamics in the market of particular procedures.<sup>13</sup> This may help

## ABSTRACT

**OBJECTIVES:** The number of anterior cruciate ligament reconstruction (ACL-R) surgeries for adolescent patients has been increasing, and so are the costs for medical care services and the general cost of living. We proposed a novel economic model assessing the cost associated with adolescent ACL-R over time and how this compared with price measures in the US economy.

**STUDY DESIGN:** Economic analysis.

**METHODS:** ACL-R surgeries performed from 2010 to 2022 in a single Level I trauma center were included. The trend of the total charge, charge of anesthesia, and operating room (OR) charge were normalized to 2010 (base year) and compared with the inflation in hospital services, medical care services, and the US economy measured by the Consumer Price Index (CPI). The actual reimbursements-to-charges percentage from the payers was analyzed. Comparing growth rates rather than dollar values circumvented any problematic direct-dollar comparisons across measures.

**RESULTS:** Analyzing 459 qualified ACL-R cases in patients whose ages ranged from 12 to 18 years, the overall total median charge increased 70%, whereas the General CPI, Medical CPI, and Hospital CPI increased 35%, 41%, and 64%, respectively. The anesthesia and OR charges increased 52% and 92%, respectively. The annual reimbursements-to-charges percentage hovered steadily beneath 50%. All inflation measures rose sharply after 2019.

**CONCLUSIONS:** The rising cost of adolescent ACL-R has been outpacing the inflation in the cost of medical services and the general economy in the US. The COVID-19 pandemic and market rigidity in medical services may have impacted these trends. Optimizing OR time usage may mitigate the rising cost.

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orthopedic surgeons and clinicians navigate cost management in the era of inflation and health care reform.

The cost of ACL-R has been reported among the general patient population<sup>14-17</sup> but less studied in adolescent patients. Further, comparing that cost over time to the medical economy can better reveal the true trend of that cost in the market. We hypothesized that the charges and reimbursements for ACL-R in adolescent patients have increased in proportion to the increase of the cost of health care in the US. We proposed a novel economic model to address the aims of the present study: to determine (1) the trend of the charges and reimbursements associated with pediatric ACL-R surgery over time and (2) how that trend relates to other price measures in the US.

## METHODS

### Patient Cohort

This study was a longitudinal economic analysis of a patient cohort in a single institution. Outpatient, arthroscopic-assisted primary ACL-R cases using autografts, performed from 2010 to 2022, were included from a Level I pediatric trauma center (Nemours Children's Hospital, Delaware Valley, also known as Nemours Alfred I. duPont Hospital for Children, located in Wilmington, Delaware). Outpatient surgical cases that were discharged on the same day of surgery and documented and billed under the *Current Procedural Terminology (CPT)* code 29888, arthroscopically aided anterior cruciate ligament reconstruction, were included. These cases then underwent individual chart review to exclude those who had additional procedures documented and billed other than the CPT codes in the range of 29880 to 29883 (partial meniscectomy and/or meniscus repair), such as those who had simultaneous multiligamentous reconstruction or combined osteotomies for congenital knee anomalies.

### CPI and Health Care Expenses

In short, the General CPI reflects the prices of daily living costs in the US. This is a widely known index to assess inflation in the general economy. The Medical Care Index, also referred to as Medical CPI, similarly can reflect the overall prices that medical care costs. This includes the broad spectrum of health care such as professional services, hospital-related services, medical equipment, dentist and optical services, pharmacy services and prescriptions, and health insurance costs.<sup>10</sup> The Hospital CPI reflects only the prices of services performed and billed by a hospital, whether inpatient or outpatient. Therefore, whereas the Medical CPI catches more of the full picture of medical services, the Hospital CPI offers a more focused index of surgical procedures commonly performed under a hospital system.

## TAKEAWAY POINTS

The findings of this study provide insight for health care facilities and clinicians for future consideration of cost-effectiveness and value-based care for an important and common surgical procedure performed to help young patients stay active.

- ▶ The cost of anterior cruciate ligament (ACL) reconstruction surgery for adolescents has outpaced the inflation of the general economy.
- ▶ The cost of ACL reconstruction surgery has also outpaced the inflation of medical care services.
- ▶ The charges from the operating room (OR) have been a main cost driver and are related to the time, equipment, and materials used for the surgery, in addition to anesthesia charges.
- ▶ Improving surgical health care efficiency (such as maximizing OR time usage) and implementing value-based health care may mitigate the rising cost.

The values of these indices were obtained from the official website of the US Bureau of Labor Statistics.<sup>9,10</sup> The growth of these indices was then determined using the same base year of 2010 (assigned as 1.0) and reported as a ratio normalized to the base year. By comparing growth rates rather than dollar values, we circumvented any problematic direct-dollar comparisons across these measures.

### Charge Data Analysis

Descriptive statistical analysis was performed for the cohort who were included in the study. The total charge data were extracted by the hospital's billing department and included (1) operating room (OR) charges resulting from the use of OR time, implants and materials, use of intraoperative fluoroscopy, and the time of the supporting staff in the OR; (2) anesthesia charges including nerve block services; (3) procedure charges directly resulting from billing the surgical procedure code(s); and (4) other hospital charges during the surgical encounter for the perioperative care immediately before and after the outpatient procedure, but excluding the charge incurred from clinic visits and associated preoperative imaging studies such as diagnostic radiographs and MRI and preoperative or postoperative rehabilitation and physical therapy.

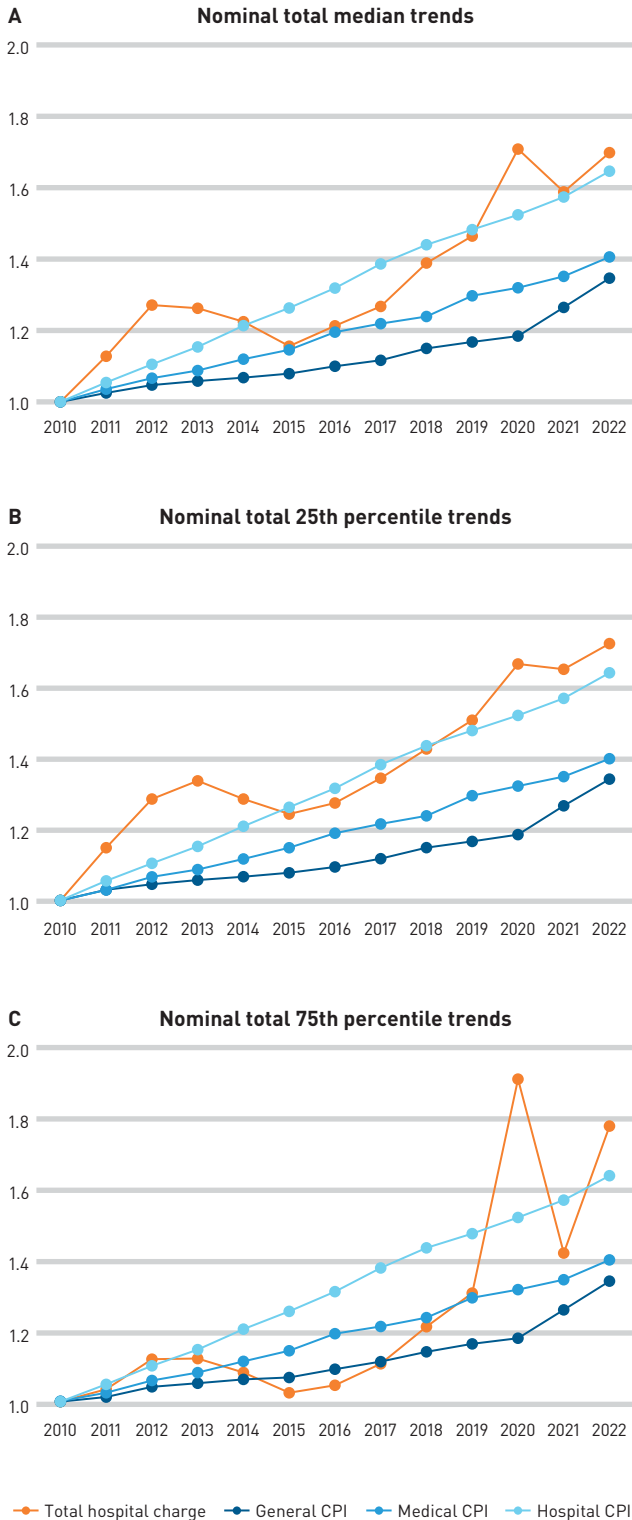
The charge data were collected as their nominal values in US\$; for each calendar year from January 1 through December 31, the distribution of the data was determined; the 25th, 50th (median), and 75th percentile data points across the distribution were then normalized to the base year of 2010, which was set to 1.0, to reveal the percentage of growth for each of the 3 percentile marks. This approach was chosen because (1) this enables the comparison of these charges to the trend of the CPIs, which were normalized to the same base year to reflect inflation, and (2) the actual nominal dollar values are considered confidential information in our institution.

### Subset Analyses

In addition to the total charges, subset analyses were performed on the charge data focusing solely on (1) OR charges and (2) anesthesia charges. These were of interest because they were reported in the literature to be the main cost drivers for ACL-R procedures.<sup>18</sup>

Another subset analysis was performed by categorizing the cases into those who used public sector health plans and those

**FIGURE 1.** The Trend of Growth of Total Hospital Charge of ACL-R, With Its (A) Median, (B) 25th Percentile, and (C) 75th Percentile Data Points



ACL-R, anterior cruciate ligament reconstruction; CPI, Consumer Price Index.

who used private sector health plans. The public sector plans included Medicaid, State Children’s Health Insurance Programs, and TRICARE.

Meniscus tear is the most common injury associated with ACL ruptures and typically requires surgical treatment at the time of ACL-R. We performed a separate subset analysis comparing the overall charge of stand-alone ACL-R vs ACL-R with concomitant procedures. The access to these detailed data was limited to only a portion of all cases from 2010 to 2019 due to financial confidentiality. Thus, this analysis was not performed on all cases of the full time frame of the present study between 2010 and 2022.

### Reimbursements-to-Charges Percentage

The percentage of actual reimbursements received from the payers was analyzed based on accessible data. This took the form of overall percentage of reimbursements/charges received by the institution by calendar year (January 1 to December 31) at the 25th, 50th (median), and 75th percentiles.

## RESULTS

### Overall Charge vs CPI

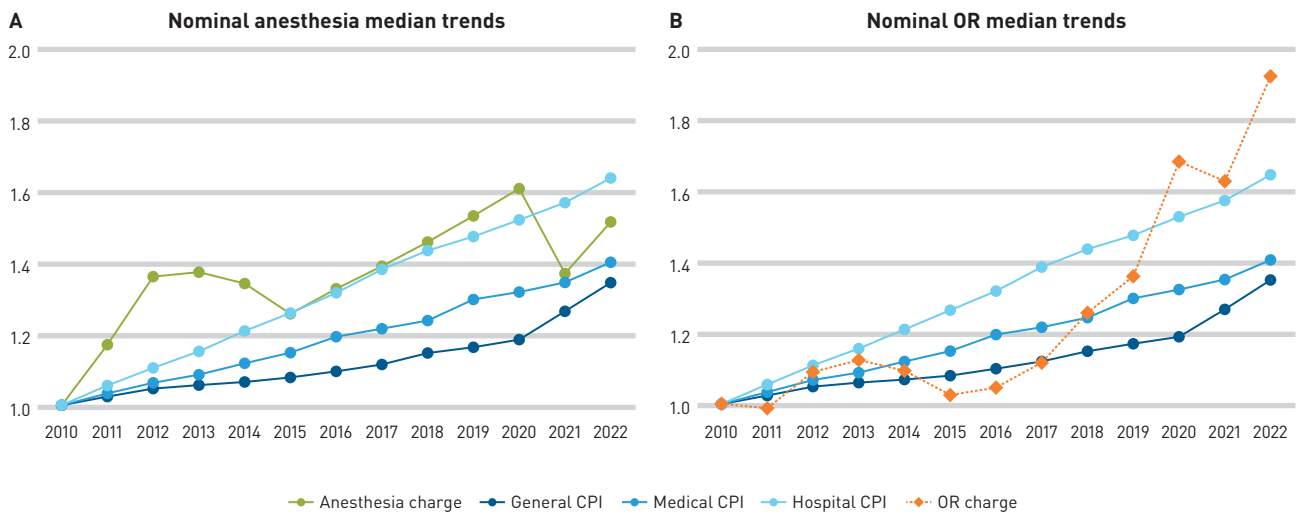
A total of 459 of 538 ACL-R cases qualified for analysis; 79 cases were excluded because additional procedures other than those CPT codes defined in the inclusion criteria (29880-29883) were performed in these cases (eAppendix Figure 1 [eAppendix available at [ajmc.com](http://ajmc.com)]). The median age of the cohort was 15 years (range, 12-18). From 2010 to 2022, the overall total median charge increased 70%, whereas the General CPI, Medical CPI, and Hospital CPI increased 35%, 41%, and 64%, respectively (Figure 1 [A]). The 25th and 75th percentiles of the overall total charge increased 73% and 79%, respectively (Figure 1 [B and C]). The 25th, 50th (median), and 75th percentiles of the total charge shared a similar trend of a slight decrease from 2012 to 2015, followed by a bounce-back afterward.

From 2010 to 2022, the median of anesthesia charges alone increased 52% (Figure 2 [A]); the median of OR charges alone increased 92% (Figure 2 [B]). The anesthesia charge followed a trend across the years similar to that of the overall charge, whereas the OR charge remained relatively stable until 2015, when it started to increase sharply. More details for this subset analysis can be found in eAppendix Figure 2.

### Public vs Private Sectors

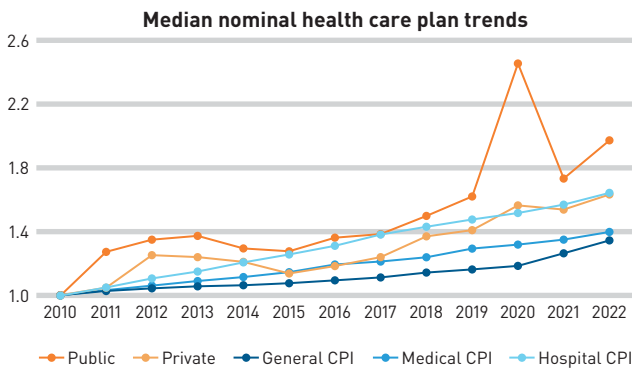
A total of 133 cases used public sector health care plans and 326 used private sector plans. There was a noticeable increase in the median charge among cases who used public sector insurance, which peaked at an increase of 146% in 2020 and trended toward 80% in 2022. For those who used private sector insurance, the growth of median charge had been relatively steady and on par with the Hospital CPI (Figure 3). More details can be found in eAppendix Figure 3.

**FIGURE 2.** The Trend of Growth of (A) Anesthesia Charge and (B) OR Charge, Presented With Median Data Points



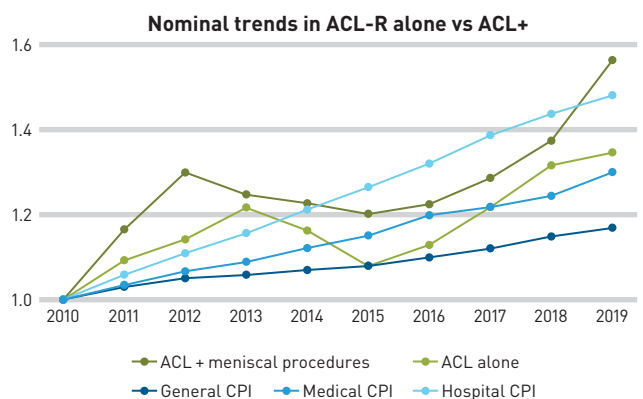
CPI, Consumer Price Index; OR, operating room.

**FIGURE 3.** The Trend of Growth in Hospital Charge, Comparing Cases Using Public vs Private Sector Health Care Plans, Presented With Median Data Points



CPI, Consumer Price Index.

**FIGURE 4.** The Trend of Growth in Total Charge Comparing Cases Undergoing ACL-R Alone vs ACL-R With Concomitant Procedures (ACL+), Presented With Median Data Points



ACL-R, anterior cruciate ligament reconstruction; CPI, Consumer Price Index.

### ACL-R Alone vs ACL-R and Concomitant Procedures

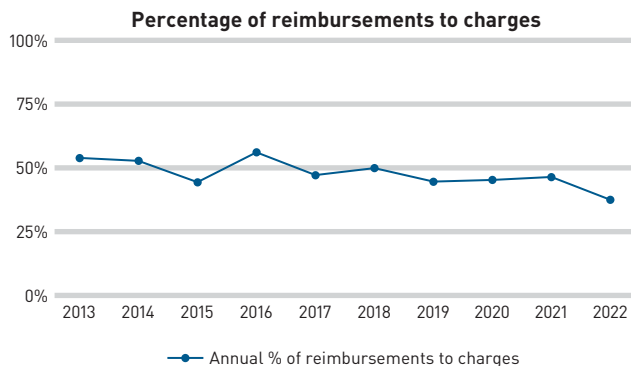
For the specific breakdown regarding whether the charges included concomitant procedures, the data were accessible only from 2010 to 2019, for a total of 322 out of 459 for this subset analysis. Among them, there were 131 cases who underwent only a single ACL-R procedure and 191 cases who also had concomitant procedures.

In the studied time frame until 2019, the median total charge increased 35% for ACL-R-only cases and 56% for ACL-R with concomitant procedures. In the same time frame, the General CPI, Medicare CPI, and Hospital CPI increased 17%, 30%, and 48%,

respectively (Figure 4). Thus, from 2010 to 2019, the Hospital CPI appeared to have grown higher than the charge of ACL-R-only cases, but not as much as the ACL-R with concomitant procedures.

### Reimbursements-to-Charges Percentage

The reimbursement data were available for access from 2013 to 2022, only in the form of the percentage of charges that the institution actually received for reimbursement. The overall annual reimbursement received from all payers ranged from 37% to 56% of the charges, with a slight trend of decreasing over the years (Figure 5). Among

**FIGURE 5.** The Trend of Annual Actual Reimbursements-to-Charges Percentage of ACL-R Cases

ACL-R, anterior cruciate ligament reconstruction.

all payers during this time frame, the median reimbursements-to-charges percentage was 46%, and the 25th and 75th percentiles of such reimbursement percentage were 38% and 55%, respectively.

## DISCUSSION

The financial burden of ACL-R to both payers and patients has been rising. The growth in ACL-R charges outpaced both the increase in the overall cost in US health care services (Medical CPI) and the inflation in the general economy (General CPI). The actual annual reimbursements-to-charges percentage for ACL-R hovered steadily beneath 50%. Therefore, the findings lead us to reject the hypothesis that the charges and the actual reimbursement would grow at the same pace as the inflation of medical care. Further, because charges and reimbursement data exhibited a positive correlation, rising charges can serve as a reasonable proxy indicative of rising cost.

The drivers behind this trend may include rising costs of inputs, which are the costs incurred when creating a particular product or service, such as cost for newer technologies and implants or paying the rising salaries of supporting staff. Despite the increasing cost, the case numbers of adolescent ACL-R have been climbing, corresponding to the rising incidence of adolescent ACL injuries.<sup>19-21</sup> This implies that necessity of ACL-R surgery continues to be recognized for this population.

Timely ACL-R benefits the health of pediatric and adolescent patients. Physically, this surgery mitigates the risk of accelerated intra-articular injuries resulting from an unstable knee.<sup>5-8</sup> Furthermore, it improves quality of life by increasing the possibility that the young patient can return to their desired activity level.<sup>2,22</sup> Achieving a better health status may also decrease the payout from the patient's insurance and thus benefit the payers in return.

The recent COVID-19 pandemic may have impacted both the general cost of living and the cost of health care services. Traditionally, the cost of medical care increased at a faster rate than the CPI. For

example, from 2010 to 2019, the CPI increased 17%, indicating an inflation rate that was on average less than 2% per year, whereas the cost of health care and hospital services increased 30% (on average 3.0% per year) and 48% (on average 4.5% per year), respectively. From 2019 to 2022, the CPI sharply increased at 4.6% per year as the economy was hit by the pandemic, whereas the costs of health care and hospital services have grown steadily at 3.1% and 3.6% per year, respectively.<sup>9,10</sup> Similar peaks and trends from 2019 forward were also observed in both public and private sector health plans. This may be because the price tags for health care services are largely prearranged in the public sector and negotiated before the year begins, possibly resulting in lagged growth in charges. It could also be the case that the demand-supply chain in this unique medical industry has not been impacted by shortages of supply or materials as much as in the other lines of business.

In addition, market rigidities such as regulations and insurance-provider networks can play an important role. It may be noted that General CPI includes both goods and services, the former of which have experienced more muted price growth due to globalization and the importation of less expensive products. Globalization's impact is not felt so keenly in the provision of services, and in particular medical services, wherein certain market barriers to entry may persist (eg, market concentration, regulations, and insurance-provider networks); these may then foster an environment of greater charge growth.<sup>23</sup>

### Limitations

The present study has certain limitations. First, the charge data were drawn from a single medical center and may not be generalizable to all medical settings, as the charge for each service provided to complete an ACL-R procedure can vary from one facility to another. Second, the payers may have different schedules from one geographic location to another. In addition, part of our subset analyses was restricted by confidential data access that did not encompass the full study time frame of 2010 to 2022, and thus may introduce selection bias.

Despite these limitations that were partially due to financial confidentiality, we provided insight into the dynamics of the charges and costs of this very common outpatient procedure in adolescent sports medicine from the largest pediatric hospital system in the state and the surrounding area. Although charges are not directly comparable to CPI measures that are based on expenditures by consumers and third-party payers, by using growth rates of each, we made growth trends in these data directly comparable and mitigated any problematic direct-dollar comparisons between charges and actual payments and expenditures.

## CONCLUSIONS

Empirical evidence in the present study suggested that the growth in hospital charges, and the resultant reimbursement from the payers, for ACL-R far outpaced the growth of General CPI and, to a lesser



extent, the growth of Medical CPI and Hospital CPI. Anesthesia charges and OR charges appeared to be key drivers of this increase. Thus, utilizing OR time efficiently may be one strategy that orthopedic surgeons could consider to save charges. Additional detailed data could enable the discerning of the specific root of these trends by further subcategorizing the cost of items such as labor, materials, and procedure fees. Future extensions to this research include expanding our data set to contain additional institutions or a registry database that provides accessible financial information. Finally, although we have examined hospital charges and received reimbursement for ACL-R procedures, future work could use a value-based framework to analyze patient-doctor decisions and payments made by patients and families. ■

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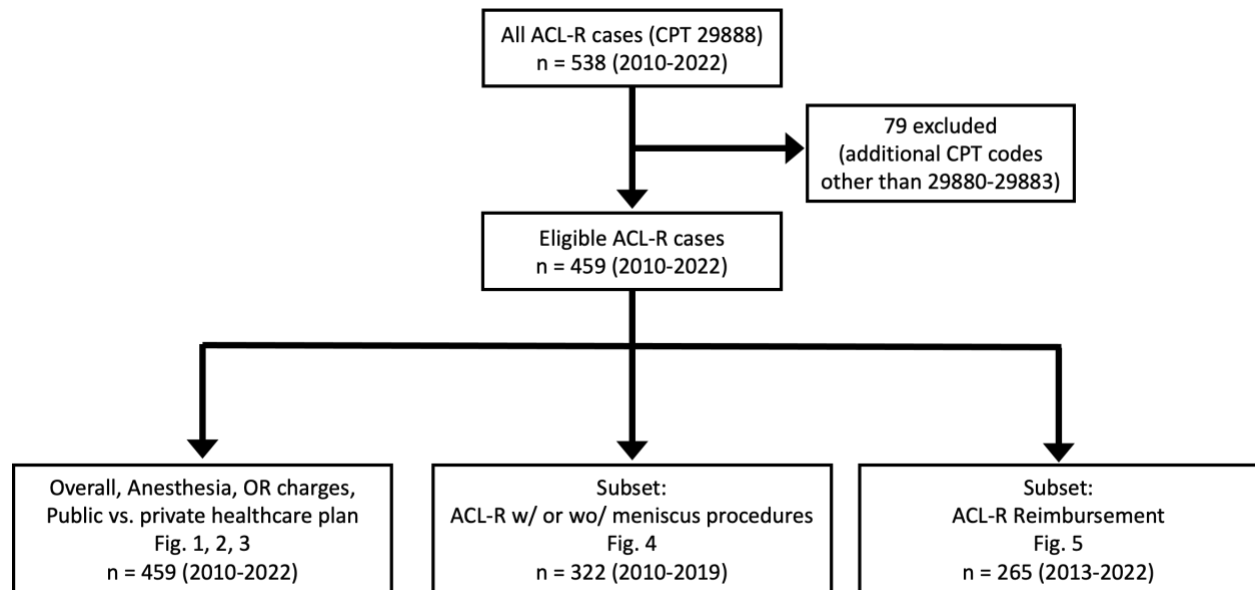
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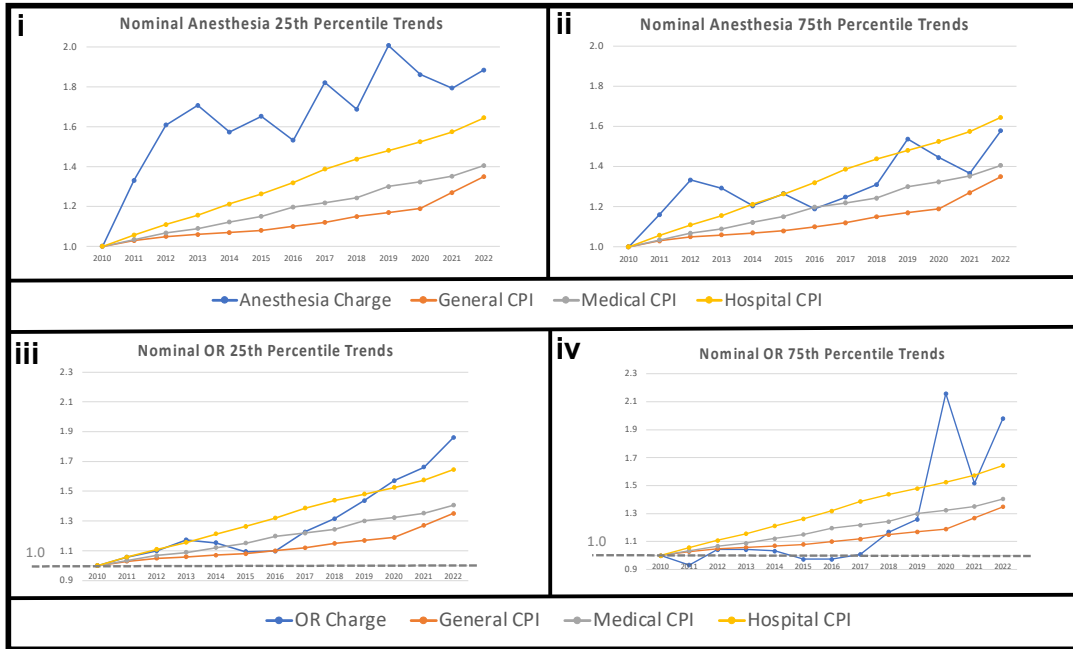
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**eAppendix Figure 1.** Flowchart of anterior cruciate ligament reconstruction (ACL-R) cases inclusion, exclusion and subset analyses. (*w/ or wo/*: *with or without*)



**eAppendix Figure 2.** The growth of anesthesia charge from year 2010 (set as 1.0) to 2022, presented with its **(i)** 25<sup>th</sup> percentile, and **(ii)** 75<sup>th</sup> percentile data points; the growth of operating room (OR) charge from year 2010 (set as 1.0) to 2022, in its **(iii)** 25<sup>th</sup> percentile, and **(iv)** 75<sup>th</sup> percentile data points.





**eAppendix Figure 3.** The growth of total charge for ACL-R comparing those who used health care plans from public sectors vs. private sectors, from year 2010 (set as 1.0) to 2022, presented with its (i) 25<sup>th</sup> percentile, and (ii) 75<sup>th</sup> percentile data points.

